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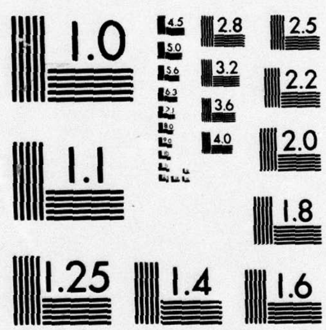

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INVESTIGATIONS OF THERMOPHYSICAL PROPERTIES OF POLYMER CONCRETES

by

A. V. Chermenskaya, Yu. A. Sokolova,
et al.

FOREIGN TECHNOLOGY DIVISION

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INVESTIGATIONS OF THERMOPHYSICAL PROPERTIES OF POLYMER CONCRETES

By: A. V. Chermenskaya, Yu. A. Sokolova, et al.

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	*α*	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Τ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ	κ *κ*	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}
rot	curl
lg	log

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INVESTIGATIONS OF THERMOPHYSICAL PROPERTIES OF POLYMER CONCRETES

A.V. Chermenskaya, Yu.A. Sokolova, G.M. Sokolov, V.A. Voskresenskiy, Kazan' Engineering and Construction Institute

It is known that epoxy polymers are widely used in construction as binding polymer concretes, polymer glues and anticorrosion coatings, which must be stable at temperatures of -40° C to +60°C [1]. However, the thermophysical properties of similar systems have been insufficiently studied.

The purpose of this investigation was to study the behavior of the epoxide compositions with heating by thermomechanical and thermographic methods. Studied simultaneously was the change in strength and deformativity of the epoxide compositions on a base of diane resins at different temperatures.

Objects of the investigation were epoxy polymers of brands ED-5 (epoxy number K = 23.5), ED-6 (K = 17.0), EDP (K = 13.5), EDL (K = 8.0) with curing agents: polyethelene polyamine (PEPA) [ПЭПА], dicyandiamide (DTsD)[ДЦД], with fillers - Portland cement, ground quartz sand (PKM)[ПКМ], Zonolite and graphite. Tests were conducted at temperatures of +20°, +45°, +70°, and +100°C. Before the beginning of the tests the specimens were held in a thermostat for 30 minutes at the temperatures indicated above.

Thermomechanical curves were taken at a compressive load, equal to 2.3 kg/cm^2, constantly acting on the specimen. The heating rate of the specimens was 4° per minute. A differential-thermal analysis was conducted on the photorecording pyrometer of Kurnakov FPK-59 at a heating rate of 5° per minute.

To establish the optimal conditions of heat treatment of the compositions using polymers ED-5 and ED-6 as a base with hardener

PEPA, tests of their physicomechanical properties and heat resistance were conducted.

Since the thermophysical properties based on cellular polymers are determined to a significant degree by their composition and mode of hardening, established by the thermomechanical method, first of all, were the dependences of the softening T_p on the form and quantity of the filler, hardener, and plastisizer and also the temperature and time of the heat treatment (Fig. 1).

From the data of Fig. 1 it is evident that with an increase in the content of the filler, T_p for all compositions of cold hardening increases insignificantly (curves 1, 2, 3). For the unfilled additionally heat-treated compositions (optimal conditions of heat treatment are 4 hours at 150°C), quantity T_p is considerably higher and consists of approximately 100°C. Whereas for compositions with the filler PKM (curve 2') with an increase in the content of the filler from 0 to 400 parts by weight a significant increase in T_p is observed, for compositions with Zonolite (curve 1') and graphite (curve 3') there occurs a considerabe increase in the heat resistance with an increase in the filler of 0 to 150 parts by weight [pw]. Here it should be noted that the compositions with a content of 150 pw of graphite (maximum filling) has T_p = 175°C. A higher T_p for compositions with Zonolite and graphite should be referred to owing to the developed specific surface of these fillers in comparison with the PKM, which allows the polymer to be distributed in the form of thin oriented films on the surface of the filler, and this, as is known [2], increases the intermolecular interaction between the polymer and filler.

However, the given effect appears only in the heat-treated compositions. It should be noted that all the tested compositions based on polymers ED-5, ED-6 and E-40 of cold hardening (without additional heat treatment) have heat resistance of the order of 45-55°C irrespective of the form and quantity of the filler.

Tests of compositions based on polymer ED-5 at increased temperatures showed that the dependence of $\sigma_{изг}$ on the degree of

has a complex nature. The lowering of $\sigma_{\text{изг.}}$ at a small degree of filling can be explained by the absence of the process of structuring and disintegration of the structure of the polymer material. At large doses of the filler there is observed a rise of the curve, which can be explained by the beginning of the formation of the spatial structure between particles of the filler and the synthetic binder. However, with a further increase in the degree of filling (more than 500 pw) there is observed a drop in the curves, which is connected with the disruption of the continuity of the resin phase with an excess of the filler [3].

The change in T_p as a function of temperature of hardening for the composition (composition is in pw: EDL - 100, DTsD - 5, PKM - 150) is given in Table 2.

As the experiments showed, T_p can be determined by the method of DGA[ΔГA - acronym unknown], and we can trace the change in this indicator depending on the different factors. We judged the heat resistance of the epoxy filled compositions on curves of DTA[ΔTA - acronum unknown] from values of minima of endoeffects, which characterize the softening temperatures (T_p) and decomposition of the polymer. Here it is necessary to note the great convergence of determining T_p by the method of DTA and thermomechanical method (divergence consists of less than 1%).

Figure 2 gives the change $\sigma_{\text{изг}}$, $\sigma_{\text{p.o}}$ of the epoxy compositions depending on the temperature of the test. Quantities $\sigma_{\text{изг.}}$ and $\sigma_{\text{p.o}}$ of epoxy glues are changed differently: to a lesser degree $\sigma_{\text{p.o}}$, which can be explained by the orienting effect of the substratum on the adhesive. Approximately at t = 100°C a substantial drop in $\sigma_{\text{p.o}}$. is begun. This confirms the position of the fact that the temperature of the operation of the thermoreactive polymers should be 20% lower than T_p; i.e., in the given case $T_{\text{эксп}}$ = 80-85°C [4].

It should also be noted that at a temperature of 50°C for all the tested epoxy hardened compositions there is begun a noticeable lowering of both the adhesive and cohesive properties.

Table 3 gives data on the change in $\sigma_{\text{изг}}$ of epoxy

compositions of hot hardening depending on the temperature of the test.

From the data of Table 3 it is evident that the compositions based on the polymer EPD at 20°C have greater strength than those based on the EDL. However, at a temperature of the test of +70°C values of $\sigma_{изг.}$ converge, and with a further increase in the temperature of the test the strength of the composition based on the polymer EDL exceeds the strength of the composition based on the polymer EDP.

It should be noted that with an increase in the temperature of the test, the $\sigma_{изг}$ of compositions 1 are lowered by 20% and of compositions 2 - by 6%, which can be explained by the large molecular weight of the polymer EDL [5].

Conclusions

1. The thermophysical properties of epoxy compositions by thermomechanical, thermographical and standard-mechanical methods were studied.

2. It is shown that the compositions of the cold hardening with different methods of filling and modification have a heat resistance not higher than +60°C, since the processes of hardening "in the cold" do not occur completely.

3. It is established that the greatest heat resistance to the compositions based on polymers ED-5 and ED-6 with hardeners of cold hardening is provided for by the subsequent heat treatment according to the conditions of 150° - 4 hours, and to compositions based on the EDP and EDL with dicyandiamide as the hardener in conditions of hardening of 200°C - 45 minutes.

4. Given is an interpretation of the extremal changes of the thermographic and thermomechanical indices with a different content of the filler.

Bibliography

Table 1

1 Свойства композиций	2 Режим термообработки				
	10 час (3) 80° C	6 час (3) 100° C	4 час (3) 150° C	6 час (3) 150° C	4 час (3) 170° C
$\sigma_{изг}$, кгс/см²	870	865	940	927	865
$\sigma_{сж}$, кгс/см²	1318	1425	1420	1412	1400
$T_р$, °C	98	100	110	108	101

Note: Prior to heat treatment the specimens were hardened for 72 hours at 20±2°C.

KEY: 1) Properties of composition; 2) Mode of heat treatment; 3) hour.

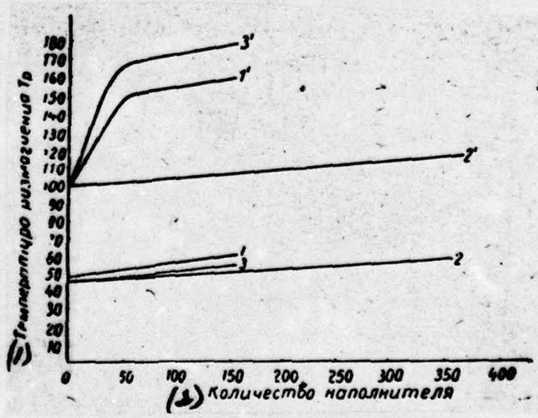

Fig. 1. Dependence of T_P of epoxy compostions (composition in pw: ED-5 - 100, PEPA - 20, filler) on the kind and quantity of filler. KEY: 1) Softening temperature; 2) Amount of filler.

Table 2. Change in T of certain epoxy compositions as a function of the hardening temperature

(1) Температура отверждения, °C	160	180	200	220	240	260
T р, °C	101	112	119	126	118	110

KEY: 1) Temperature of hardening, °C

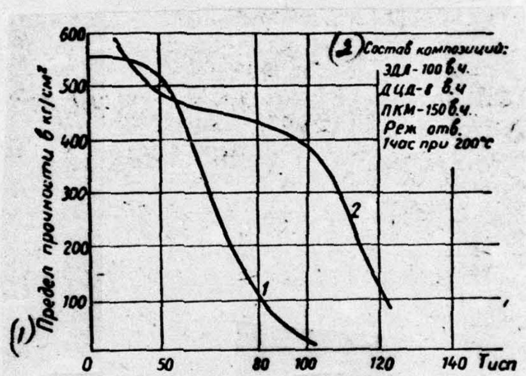

Fig. 2. Change in $\sigma_{изг}$ (1) and $\sigma_{р.о}$ (2) of epoxy composition (composition in pw: EDL - 100, DTsD - 8, PKM - 150) as a function of the temperature of the test. KEY: 1) Limit of hardness in kg/cm^2; 2) Composition of compositions: EDL - 100 pw, DTsD - 8 pw, PKM - 150 pw; Mode of hardening - 1 hour at 200°C.

Table 3

Change in $\delta_{изг}$ of epoxy compositions of hot hardening as a function of temperature of the test

(1) № п. п.	(2) Состав композиций в вес. частях	(3) $\sigma_{изг}$ при t испытания в °C		
		+20	+45	+70
1	ЭДП+ДЦД+цемент (100 : 8 : 150)	602	544	485
2	ЭДЛ+ДЦД+цемент (100 : 5 : 100)	531	515	501

KEY: 1) No.; 2) Composition of compositions in parts by weight(pw); 3) with t of the test in °C; 4) EDP+DTsD+cement; 5) EDL+DTsD+cement.

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